

Measurement of Flexible Cooling Link Conductance for X-Ray Monochromator Applications

J. Kelly, V. Mykhaylyk, Diamond Light Source, Harwell Science and Innovation Campus, Didcot, Oxon OX11 0DE

Introduction

A test rig was built and used to measure the thermal conductance of cooling links commonly in use at the Diamond Light Source Ltd, UK (DLS).

Motivation for Study

The thermal conductance of Double Crystal Monochromator (DCM) 2nd crystal cooling braid assemblies, defines two main operational parameters, 2nd crystal temperature and the thermal stabilisation time. There is also a balance between thermal conduction and mechanical isolation, because typically the links must allow for 2-3 degrees of freedom.

A large spread in published data makes it difficult to apply to the thermal links commonly used. A better knowledge of thermal links, will aid future design as well as upgrades to existing instrumentation.

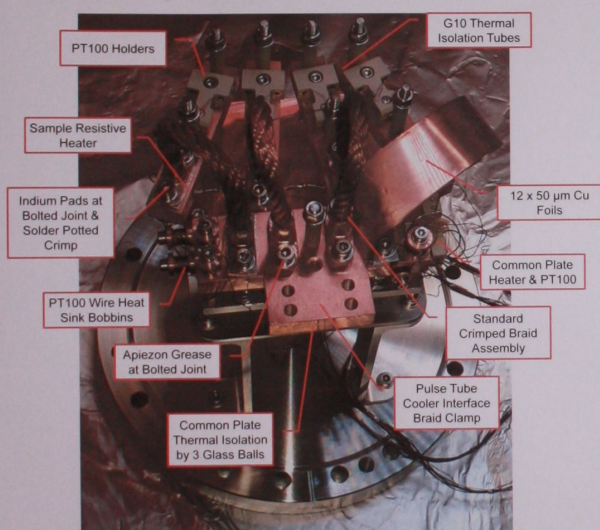


Figure 1: Test Rig assembled with three braid links and one foil stack

Test Set-Up

The assembly shown above was mounted inside a vacuum vessel and connected to a Pulse Tube Cooler. The PT100 temperature sensors were read by a Lakeshore controller and recorded by the standard EPICS PV archiver. A manual power supply was used for the sample heaters which were wired in series. The Lakeshore was used to drive the common plate heater in closed loop. A schematic of the test rig is given in Figure 2.

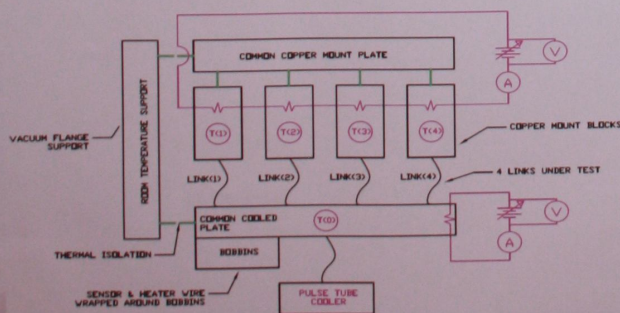


Figure 2: Diagram of the electrical and thermal connections of the test rig.

Results

The four different samples tested were:

1. A crimped braid assembly with an Indium layer at the bolted interfaces and solder potted crimped interfaces
2. A crimped braid assembly with grease at the bolted interfaces
3. A standard typical plain Cu crimped braid assembly
4. A stack of 12, 150 mm long by 25 mm wide, 50 µm thick OFHC foils.

The OFHC braid used had a cross section area of 16 mm² and an exposed length of 100 mm. The foil stack had an exposed length of 125 mm and a cross sectional area of 15 mm².

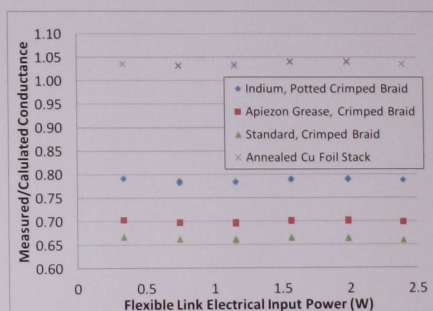


Figure 3: Thermal link efficiency (Measured Conductance/Calculated Bulk Conductance). Data taken with a common plate temperature of 226 K.

The data presented in Figure 3 have been compensated for:

- Thermal conduction through the G10 supports and electrical wires
- Black Body Radiation from the vessel walls and surrounding structure
- Electrical resistance of the heater wires
- PT100 systematic error caused by a resistance offset

The measured conductance values post error correction were: Solder potted braid 0.050 W/K, greased joint braid 0.045 W/K, standard braid 0.042 W/K and foil stack 0.050 W/K. The applied corrections slightly changed the absolute conductance values but not the relation between them.

Conclusion

The 100 mm long crimped braid assembly commonly used at DLS, has a thermal conductance of 0.04 W/K in the 100 to 260 K temperature range.

The foil stack tested had a similar cross section to the braid and similar conductance but a 25% greater length and a higher flexibility. The superior conductance is due to the low contact resistance at the interfaces, caused by the very compliant, smooth, oxide free, annealed foil stack, as compared to a milled Cu block.

The foil thermal links have been successfully utilised on the I09 & I23 DCMs at DLS, to conductively cool the 2nd crystal via the 1st crystal manifold providing equivalent cooling but superior mechanical isolation to the original braid assemblies.

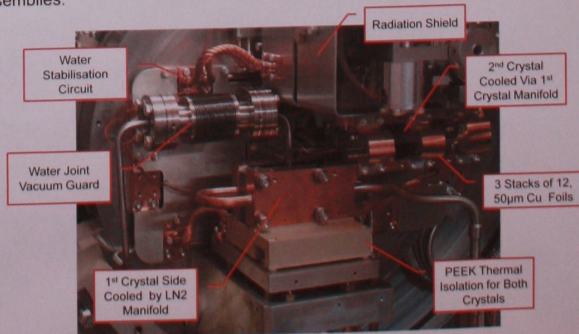


Figure 4: I23 DCM using Cu foil stacks to cool the 2nd crystal reducing the mechanical influence observed with Cu braids.